Can man still beat the machine? Automated vs. manual pattern recognition of 3D MRSI data of prostate cancer patients

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Introduction

Mortality of patients with prostate cancer is only 5%. Unfortunately, the determination of patients who will develop a highly infiltrating and metastasizing tumor is currently not possible. By means of magnetic resonance spectroscopic imaging (MRSI), metabolites such as citrate (Ci) and cholines (Cho) can be detected *in vivo*. Since the concentration ratios of these compounds change characteristically in pathologic tissue, MRSI is in principle well suited for the detection and localization of prostatic tumors [1]. However, since the data load generated by 3D MRSI is tremendous, introducing MRSI into clinical routine is a major challenge due to the necessary postprocessing and evaluation of the acquired spectral volumes.The purpose of our study was to compare the capability and advantages provided by an automated evaluation tool for 3D ^{1}H MRSI data of patients with prostatic cancer with a "manual" evaluation of the same data.

Material and Methods

Ten consecutive patients with biopsy–proven prostatic cancer who were scheduled either for prostatectomy (5) or radiation therapy (5) were included in this study. Localized *in vivo* ^{1}H MR spectra were obtained at B_0 = 1.5 T (Magnetom Symphony; Siemens, Erlangen, Germany) using a 3D PRESS SI sequence (TR/TE = 650ms/120ms, water– and lipid–signal suppression, nominal voxel size 6 × 6 × 6 mm^3, total acquisition time 10–12 min) [2]. SI data was analysed "manually" using the software provided by Siemens by labelling the data equivalent to the automated tool. The contrast of the underlying T2–weighted images was reduced in order to eliminate bias by T2–hypointense areas indicating tumor (Fig. 1).
The automated evaluation program CLARET is currently installed on a commodity personal computer [3]. The MRSI volume and the corresponding T2w MR image volume is read from the DICOM data set. The CLARET tool evaluated each data set in a single process. The results are displayed as color–coded probability maps superimposed on the morphological MR images (Fig. 2).

Results

The "manual" evaluation of a single data set (about 3000 spectra each, or a total of 32471) lasted from 120–180 min, although only those 24.7% (8042 spectra) that were localized in the prostate itself were chosen. The automated evaluation performed a pattern recognition of all spectra within 7–11 min depending on the number of image slices covering the whole prostate. The tool marked ca. 17% of all spectra within the prostate as "non evaluable due to insufficient spectral quality", which corresponded to the numbers of spectra rejected in the manual analysis (16%). Only 1.25% (2.2%) of all spectra from patients undergoing radiotherapy and 1.88% (2.2%) of the operated patients showed highly suspicious spectra in the automated (manual) evaluation. 3.38% of the radiotherapy group and 3.89% of the operated group showed benign spectra in the automated evaluation, while the manual evaluation revealed 5.73% and 8.47% respectively. Both methods showed the same results in 4262 spectra (52%).

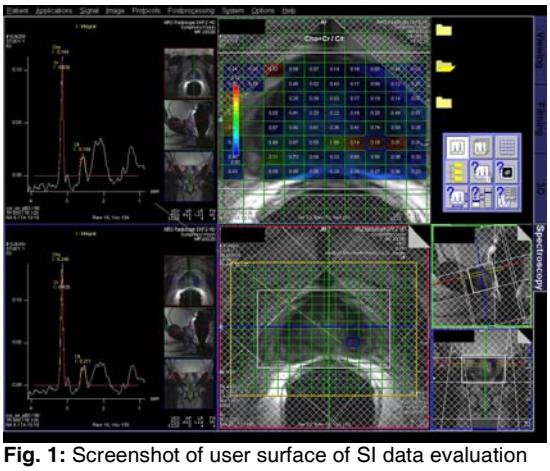

Fig. 1: Screenshot of user surface of SI data evaluation software provided by manufacturer of the tomograph.

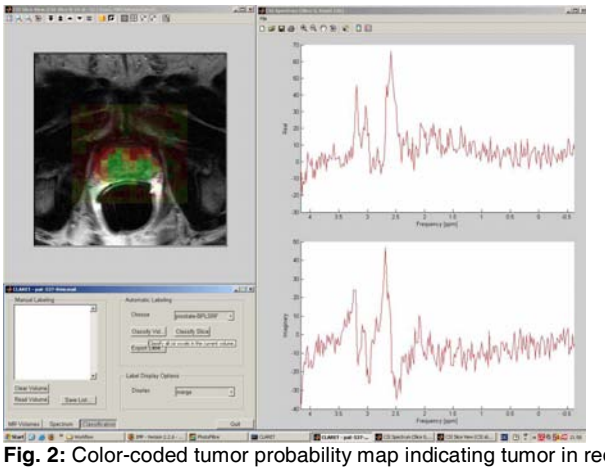

Fig. 2: Color-coded tumor probability map indicating tumor in red areas. Green areas show no pathological findings as seen in corresponding spectra.

Discussion

This study demonstrates the potential of and the need for pattern recognition methods for the diagnostic evaluation of MRSI. The fast and reliable analysis and quantification of a large amount of MR spectra with poor signal–to–noise ratio and frequency resolution can predefine the utilizable spectra. In contrast to other tools, CLARET is tailored towards the generation and visualization of pathophysiologic maps: a tumor probability is assigned to each voxel. In the subsequent diagnosis, the user can therefore concentrate on regions marked as suspicious. In doubtful cases the corresponding spectrum can easily be inspected and also conspicuities in the T2w images can be considered. However, in order to compare both methods we avoided the bias of the underlying T2w image in the manual evaluation; these images certainly help, especially for voxels near the prostate capsule and the central gland around the urethra, to decide whether the spectra are evaluable. The "manual" approach still seems superior in identifying a slight decrease of citrate levels which an automated tool would not consider as suspicious. A combination of both methods seems to be a good approach for the spectroscopist to cut down time constraints in clinical routine, without completely abandoning manual evaluation of MRSI data with respect to tissue specific domain knowledge. Finally, manual evaluation certainly lacks objectivity and reproducibility which is indicated by the higher amount of benign spectra in manual evaluation. Nevertheless these aspects can be traced back by an automated tool as described above.

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